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Bending Machine for Profiles and Circular Pipes

The invention relates to a bending machine for profiles and circular pipes according to the generic portion of claim 1.

A bending machine for the bending of circular pipes was disclosed as the object of DE 196 30 025 A1. With this machine, circular pipe profiles can be freely bent in the 2D and 3D sector. The production throughput of the known bending machine is, however, limited to slow passage speeds with low degrees of reshaping. A similar arrangement is disclosed by DE 40 41 668 A, wherein a profile that is to be bent is pushed by a mandrel tool and reshaped by a three-roll bending arrangement that consists essentially of pairs of support rolls, pairs of rolling rolls, and pairs of bending rolls arranged in succession. The pairs of bending rolls were arranged on a table displaceable in three mutually perpendicular directions (X, Y, Z-direction); thus free bending was possible.

However, there was only a minimal passage speed for the profiles that is to be bent since there is no drive for the rolls; and, moreover, only a very slight bending was possible since the entire bending roll arrangement was arranged on an coordinate table adjustable in three directions.

Consequently, the object of the invention is to improve a bending machine for profiles and circular pipes of the type cited in the introduction such that substantially higher passage speeds with higher degrees of reshaping may be obtained.

To accomplish the object indicated, the invention is characterized in that the bending head consists at least of the sequential arrangement of a pair of support rolls, a

pair of rolling rolls downstream therefrom, followed by at least one bending roll, wherein the bending roll is arranged in a fixed manner on a rotary disk the turning center of which is arranged parallel to the longitudinal axis of the profile to be bent at a distance therefrom, and that the rotary disk itself is part of a coordinate table adjustable in at least two directions that are perpendicular to each other.

The technical teaching reported thus yields the substantial advantage that now, instead of the arrangement of a plurality of bending rolls (e.g., even pairs of bending rolls), only one bending roll arranged on a rotatingly driven rotary disk is required, with this rotary disk in turn part of a coordinate table adjustable at least in the Y-and Z-direction.

The so-called coordinate table has in its center a port, in the region of which a rotary disk also having a port is arranged. The port in the rotary disk is essential for the feeding through of the profile that is to be bent.

The coordinate table itself now consists of two plates movable at right angles relative to each other in one plane such that the profile to be fed through the opening and to be bent is reshaped as required toward the left or right, downward or upward, or even in a combined direction when advanced depending on the adjusted position of one or the other coordinate plate by means of the bending roll such that, for example, a helix shape is produced by the bending of the profile. Obviously, all other possible shapes could be bent from the originally straight profile, such as, for example, bends with equal and/or different radii.

Of course, it is already known from DE 196 30 025 A1 that a bending roll is affixed radially movable on a rotary disk driven in rotation.
In this known arrangement, there exists, however, the disadvantage that only low speeds with low degrees of reshaping are possible. Thus, with it, only thin profiles with a

small cross-section are bent since the radial displacement drive of the bending roll, which must be affixed on the rotationally driven rotary disk, presents significant problems.

This increases as a whole the weight moved during bending such that only low passage speeds can be obtained.

In particular, the radial adjustment movement is possible with only relatively low power since the corresponding, associated power drive can be integrated into the rotary disk only with difficulty. For example, with the known bending device, no spiral can be bent from a circular pipe since the rotary drive of the rotary disk in connection with the radial drive of the bending roll achieves only a maximum of 360° in one direction.

Here, the invention provides that a radially nonadjustable, i.e., fixedly arranged, bending roll is affixed on a rotary disk and that the rotary disk itself is arranged with its rotary bearing on a coordinate plate displaceable in the Z-direction and lockable.

A radially adjustable bending roll it is now replaced according to the invention by a fixed bending roll that is arranged on a coordinate plate displaceable in the Z-direction.

In addition, the invention also provides, however, that an additional displacement motion can be applied to this bending roll in the Y-direction as well. Thus, a substantially greater freedom is obtained in the free bending of profiles. It is now possible to apply any desired bending force that one wishes without negatively affecting the bending space available because it is no longer necessary to arrange the radial displacement drive for a bending roll in the region of a rotary disk.

The drive means mentioned are thus arranged on the periphery of the bending head and are implemented in the form of coordinate plates.

Thus, the bending roll can be freely displaced in the Y-Z plane by a corresponding displacement drive of the associated coordinate plates, which was not possible in the prior art.

In this manner, now -- because of the better control in the Y-Z plane -- significantly finer adjustment movements are possible and, thus, significantly higher bending speeds may be obtained.

In addition, a multiple spiral profile can be produced, which was not possible in the aforementioned DE 196 30 025 A1.

Independent of that, and as an independent object of the invention, the invention is also based on the further knowledge that with higher speeds according to the invention, higher degrees of reshaping of profiles are also possible

Here, the invention provides that at least one of the rolling rolls of the pairs of rolling rolls present is designed adjustable in its movement relative to the profile to be bent such that, according to the invention, a rolling force on the profile to be bent can be applied to the rolling rolls.

Thus, an adjustment force is associated with at least one of the rolling rolls of the pairs of rolling rolls present, which force ensures that the rolling roll rolls out the profile that is to be bent with correspondingly high pressure and thus induces a flow process in order to then cause it to be bent dimensionally accurately by the bending roll.

Through the flow process induced, the necessary force on the bending roll is clearly reduced. Likewise, the passage speed of the profile to be bent can be increased significantly.

Through the rolling out and the flow process induced thereby, it is possible to obtain degrees of reshaping that are impossible with the use of conventional bending

technology. I.e., the ratio of the profile size or diameter to the inside radius of a profile that is to be bent can be even smaller, without risk of crack formation or minimization thereof.

In this regard it is reported that through the rolling out and the flow process induced thereby, a ratio of profile size or diameter to the inside radius of the profile to be bent of 1.5 to 1 or 1 to 1 is possible.

The rolling out process takes place precisely at the bending line of the profile to be bent, i.e., at the place at which the material changes from the bending process occur. Through the induced flow process, it is possible to carry out bending with lower bending forces than with prior art processes.

A further advantage consists in the improvement of the bending accuracy through a sharp reduction in the spring-back in the profile to be bent. Through the artificially induced flow process, caused by the rolling roll, crack formation in the microstructure is largely avoided. I.e., the stretching processes in conventional profile bending are eliminated with this bending process. These physical processes in the profile to be shaped enable a significantly higher reshaping speed compared to prior bending processes.

Additionally, there is with this process the advantage that in a single bending process any arbitrary bending contour can be obtained. In contrast, in the conventional 3-4 roll bending processes, a plurality of bending processes are necessary for the production of a finished bent shape of the profile. In contrast, with the use of the bending process according to the invention, a significantly higher production output is achieved. This yields improved material consistency of the profile to be bent, significantly gentler treatment of the surface of the profile, as a result of which postprocessing work is eliminated, e.g., pretreatment for painting or eloxation and the like.

Thus, with high cycle output, high degrees of shaping of profiles to be bent can also be achieved.

It is also pointed out that the present invention is not limited to the bending of circular pipes, but rather all open and closed hollow profiles can be reshaped.

It is certainly known to provide roll out actions with profiles to be bent in the 2D sector (cf. DE 197 33 932 A1). However, this is a core stretching bending process over predefined bending templates.

However, in the publication mentioned, the bending roll or the pair of bending rolls were moved away from the turning center of the rolling rolls in various ways during the bending process. This is undesirable for the bending of tight radii and leads, in particular, to disadvantages in the three-dimensional bending of profiles.

Thus, the bending roll should be arranged at the shortest possible distance from the pair of rolling rolls and, consequently, enable corresponding three-dimensional bending.

Here, the invention provides that the bending roll is arranged rigidly on a rotary disk and operates in the same plane as the pair of rolling rolls, with it being, however, arranged offset therefrom. There is thus no distance between the effective bending roll plane and the effective rolling roll plane, as was described in the older DE 197 33 932. This is achieved through the reduction of the resistance forces in the material to be reshaped through the flow process generated in the outer region of the profile to be bent at the rolling roll level.

There is thus the advantage with the invention that the rotary disk according to the invention can be rotated by more than 360° or by a multiple thereof, which was not possible in the prior art (DE 196 30 025A1). Because of

doing away with a radial adjustment movement in the rotary drive, it is possible, according to the invention, to undertake a significantly faster rotation of the rotary disk. This is thus a highly dynamic rotation with a lower mass, with which high cycle outputs are achieved. Thus, rapid axial slide through movements can be executed for the profile that is to be bent, which was not possible with the prior art.

It is thus important that the necessary adjustment movements at an angle to the longitudinal axis of the profile that is to be bent enable just as rapid an adjustment of the bending roll, as a result of which simpler and faster control is enabled.

The problem with rapid bending is, in fact, the overcoming of the inertia of the masses moved. The only masses moved according to the invention are the rotary disk and the drives for the coordinate plates that are arranged outwardly far from the bending roll. Consequently, within an extremely short time, the bending direction can be changed based on the rotary movement of the rotary disk, which is not possible with structurally large and heavy drives on a rotary disk according to the prior art. Consequently, according to the invention electromechanical drives are also used for the various movements, rather than comparable hydraulic drives since electromechanical drives work significantly faster and can be more precisely controlled.

The subject matter of the present invention is disclosed not only through the subject matter of the individual claims but also from the combination of individual claims among each other.

All data and characteristics disclosed in the documents, including the abstract, in particular the physical design depicted in the drawings are claimed as essential to the invention to the extent they are novel individually or in combination compared to the prior art.

The invention is illustrated in detail with reference to drawings depicting several embodiments. Additional characteristics and advantages of the invention are evident from the drawings and the description thereof.

They depict:

Fig. 1: a schematic, transverse top view of a bending machine according to the invention;

Fig. 2: the bending machine according to Fig. 1 with the cover removed;

Fig. 3: the side view of the arrangement according to Fig. 2;

Fig. 4: the enlarged side view of the bending head according to Fig. 3;

Fig. 5: the view rotated by 90° relative to Fig. 4;

Fig. 6: schematic depiction of the adjustment of the rolling roll with an adjustment device using an eccentric disk;

Fig. 7: an embodiment modified relative to Fig. 4 with application of rolling force via a different arrangement;

Fig. 8: the illustration of the principle according to Fig.7.

Fig. 1 depicts, generally, a bending machine for profiles and circular pipes that comprises a bending head 1 that is fixedly connected with the bridge 2, on which a group of guides 6 are attached at intervals.
On the rear portion of the bridge 2, a mandrel station 3 is provided for the mounting of a mandrel rod 21 and also a slide carriage 4, with which the profile 5 that is to be bent is pushed into the bending head 1.

There are two possibilities for the advance of a profile. Either one or a plurality of pairs of rolls in the bending head are rotatably driven such that they advance the profile in the longitudinal direction through their rotary movement, or in a different embodiment these pairs of rolls are not rotatably driven and the profile that is to be bent is merely pushed through the bending head 1 via a slide carriage 4.

Fig. 1 also depicts that the bending head 1 is covered by a cowling 7.

Additional details of the bending head 1 are discernible in conjunction with Fig. 2.

A vertical web plate 9, on which a first displacement drive is arranged for displacement in the Z-direction for a coordinate plate 10, is arranged on a base plate 8.

The displacement drive takes place here by means of the drive 16 for the coordinate plate 10.

On this coordinate plate 10 is arranged an additional coordinate plate 11 drivable in theY-direction, in which the drive takes place by means of the drive 26 that is attached on the coordinate plate 10. The two coordinate plates 10, 11 are thus defined relative to each other in a right-angled Y-Z coordinate system. This, in turn, is aligned at a right angle relative to the advancing direction X of the profile 5 to be reshaped such that overall there is a right-angled X-Y-Z coordinate system for the reference planes of the device according to the invention.

Rotatably mounted on the coordinate plate 11 is a rotary disk 12 parallel thereto, which rotary disk is driven in rotation via a drive belt 23 from a drive 13 that is affixed on the coordinate plate 11. A mounting 15, on which the one bending roll 14 is affixed, is connected with the rotary disk 12.

An additional details of the bending head 1 are evident from Fig. 3 and 4: In Fig. 4 it is discernible that the mandrel rod 21 passes through the profile 5 that is to be bent and a mandrel shank 22 is arranged in the interior of the profile 5, which is always held in the bending region by the drive of the mandrel station.

The bending device comprises essentially a pair of support rolls 18 on the slide carriage side, a pair of rolling rolls 17 arranged in front of that, and at least one bending roll 14 arranged in front of that.

It is pointed out that the pairs of rolls 17, 18 are present in pairs; however, they may in any case be present in two or more pairs, such that they thus can be arranged in a star pattern around the profile 5 that is to be bent.
For reasons of simplification, the following description assumes only pairs of rolls 17, 18 lying in one plan, although a plurality of such pairs of rolls may be present in different planes.

The same is also true for the bending roll 14, which is provided as only a single bending roll. In a different embodiment of the invention, provision may be made that an additional bending roll or even several bending rolls distributed around the circumference on the profile 5 that is to be bent are associated with and positioned opposite the bending roll 14 depicted.

It is important in Fig. 4 that an appropriate adjustment force on the profile 5 that is to be bent can be associated with at least the pair of rolling rolls 17 and also with the pair of support rolls 18 in the embodiment depicted.
Thus, in its simplest embodiment, the invention provides that a corresponding adjustment force can be associated with the pair of rolling rolls 17 alone by means of a corresponding adjustment drive 19.

In another embodiment -- as depicted in Fig. 4 – a corresponding adjustment force is, however, also associated with the pair of supporting rolls 18 by means of an additional adjustment drive 20.

This occurs such that a bracket 27 is applied on the vertical web plate 9 by means of a displacement guide 32, which is locked in the operating state.
The bracket 27 can thus be adjusted to adjust the distance between the pairs of rolls 17, 18 to the profile 5 by means of the displacement guide 32. This is then locked. The adjustment drives 19, 20 are arranged on the bracket 27, cf. Fig. 3, which drives act respectively on corresponding freely pivotable ends of associated levers 33, 36. This special lever principle is illustrated in further detail with reference to Fig. 6.

In any case, it is important that the respective adjustment drive 19, 20 acts on the respective point of application of force 34, 35 on the free end of one lever 33, 36 in each case and that the lever in each case bears the rotary axis 37, 48 of one roll 17, 18 in each case.

According to Fig. 6, the respective lever 33,36 is mounted with an eccentric bearing 40 on the walls of the bracket 27, whereas the respective rotary bearing 37, 48 is on the free pivotable end of the lever 33, 36 in each case.

Consequently, according to Fig. 6, a pivoting motion is exerted in the directions of arrow 47 by the adjustment drive, as a result of which the lever rotates in its bearing 40 and moves the rolls 17, 18 in the directions of arrow 49 toward and away from the profile based on the eccentric mounting of the rotary axes 37, 48.

It is further discernible from Fig. 4 that the coordinate plate 10 associated with the Z-direction is displacably mounted in a linear guide 24 on the web plate 9. The drive 16 is used for the displacement.

This consists of a pinion that engages with a corresponding rack that is part of the linear guide 24.

The displacement guidance of the coordinate plate 11 in the Y-direction occurs by means of a horizontally aligned guide, which consists essentially of guide rolls arranged in parallel near each other at intervals, that roll on corresponding guide surfaces of opposing guide rails 50 which assume a mutual interval relative to each other.

The drive 26 acts thus by racket and pinion on the coordinate plate 11.

The guide rolls 25 are affixed on the coordinate plate 10; the guide rails 50, on the coordinate plate 11.

The rotary drive 13 for the rotary disk 12 is also affixed on the coordinate plate 11. Its rotary bearing is thus arranged in the coordinate plate 11, and the profile that is to be bent is guided through by the rotary disk 12, with the bending roll 14, which is rotatably mounted in mounting 15, applied from at least one side on the profile to be bent.

The mounting 15 is fixedly attached to the rotary disk 12. The bracket 27 also has an adjustment drive in the X-direction. The bracket 27 is first fixedly connected via the connecting flange 28 with the web plate 9.

In the longitudinal direction of the profile that is to be bent, two brackets 27 are arranged parallel to each other and at a mutual interval from each other (Fig. 4 depicts only one), which brackets are connected to each other by a common bottom plate 29. A guide block 30, which is associated with its own adjustment drive 31, engages in this bottom plate 29.

The guide block 30 supports the upper rolling roll and the upper support roll 17, 18. These can accordingly be adjusted in the X-direction (longitudinal direction of the profile to be bent) against the bending roll 14.

In the drawings of Fig. 4 and 5, there are thus passive, nonadjustable lower rolls 17, 18 in addition to the upper active rolls 17, 18 that are designed adjustable both in their adjustment motion toward the profile and in the direction of the longitudinal axis of the profile.

However, the lower rolls 17, 18 may also -- in a further development of the invention -- likewise be designed adjustable in the longitudinal direction of the profile.
Thus, there is always an opposing pairing, vertically aligned with each other, of these pairs of rolls 17, 18.

The adjustment principle for the generation of the rolling force on the pair of rolling rolls or for the generation of the supporting force on the pair of support rolls was already explained with the eccentric disk 39 described there.

Whereas the eccentric disk 39 is thus affixed rotatably on the guide supports 30, the associated adjustment drives 19, 20 are affixed rotatably on the brackets 27 arranged parallel to each other. This is depicted schematically in Fig. 4 by small rotary points.

The support and rolling rolls 17,18 are in each case held in a bearing shaft 38 that is rotatably mounted on the respective lever 33, 36.

In the exemplary embodiment according to Fig. 7, modified relative to Fig. 4 and 5, a different adjustment principle is used.

Here, a "passive" lower bracket 41 is provided for the mounting of the lower rolls 17, 18 and an actively driven bracket 42 is arranged opposite it. This bracket 42 is mounted on the web plate 9 displaceably in a displacement guide 32 by a piston-cylinder arrangement with the cylinder 43, with the piston rod of the cylinder 43 acting via a plate 46 on a shoe 44 that accommodates the rotary axes 37, 38 for the rolls 17, 18.

This adjustment principle is depicted schematically in Fig. 8. It is discernible that the rotary axis 48 is fixedly anchored on one end of the shoe 44, whereas the opposite end of the shoe is designed pivotable in the directions of the arrow 47.

The rotary axis 48 is thus fixedly connected to the bracket. The shoe 44 is thus designed pivotable around this axis 48.

The rotary axis 33 for the pair of rolling rolls 17 is thus accommodated on the freely pivotable end of the shoe. Consequently, the upper rolling roll 17 can be adjusted in the directions of arrow 47 with high force based on the effect of the force of the adjustment arrangement (cylinder 43 and bearing 45) against the profile that is to be bent.

Thus, by both the arrangement according to Fig. 6 and the arrangement according to Fig. 8, because of the active, relatively high lever forces, extraordinarily high rolling forces are exerted by the upper rolling roll 17 on the profile that is to be bent.

It is also pointed out that in each case bending occurs around the rolling rolls. Depending on the bending direction, this may occur around the upper or the lower rolling roll 17 or also the rolling rolls arranged on the side at an angle (not depicted in the drawings).

If a corresponding support force is exerted on the pairs of support rolls 18 by the adjustment drives described, provision is made that the mandrel shank 22 is also located in the area below and inside the pairs of support rolls 18, to enable a corresponding support action here as well by supporting the profile from the inside.

Reference Characters

1. Bending head
2. Bridge
3. Mandrel station
4. Slide carriage
5. Profile
6. Guide
7. Cover
8. Base plate
9. Web plate
10. Coordinate plate (Z-direction)
11. Coordinate plate (Y-direction)
12. Rotary disk
13. Drive
14. Bending roll
15. Mounting (for 14)
16. Drive (for 10)
17. Rolling roll pair
18. Support roll pair
19. Adjustment drive
20. Adjustment drive
21. Mandrel rod
22. Mandrel shank
23. Drive belt
24. Linear guide
25. Guide roll
26. Drive (Y)
27. Bracket
28. Connecting flange
29. Bottom plate
30. Guide block
31. Adjustment drive
32. Displacement guide
33. Lever
34. Point of application
35. [sic]
36. Lever
37. Rotary axis
38. Bearing shaft
39. Eccentric disk
40. Eccentric bearing
41. Bracket
42. Bracket
43. Cylinder
44. Shoe
45. Bearing
46. Plate
47. Direction of arrow
48. Rotary axis
49. Direction of arrow
50. Guide rails